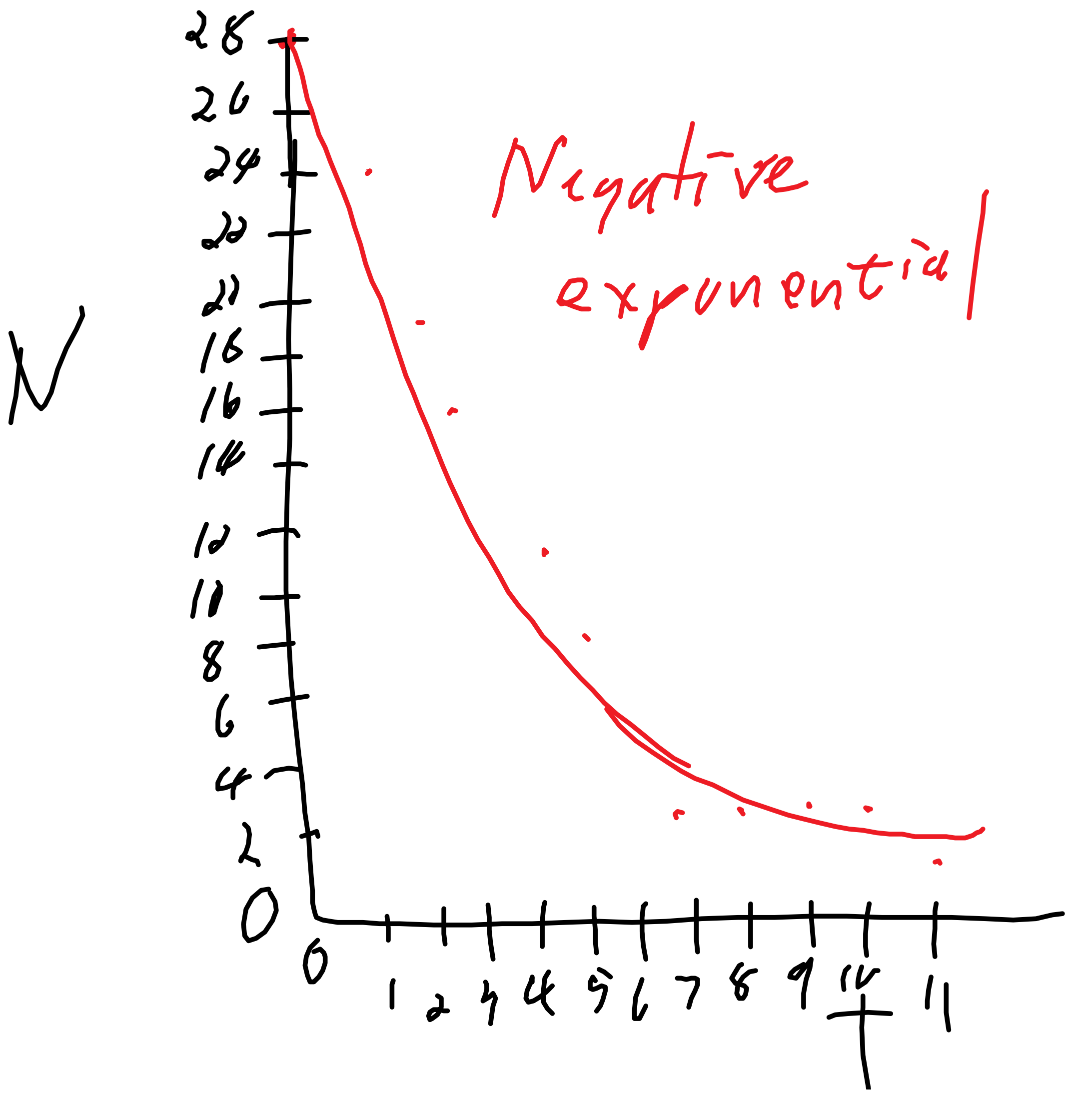
Half-Life and Binding Energy

Last class - alpha beta gamma decay
the natural decay happens randomly

Model this by each hand being a undecayed radioactive atom.
N is the number of atoms or mass of the atoms or the activity of the sample left after time t
N_o is the original amount at time t=0
t is time, in s or years or number of flips of the coin

N	t
N_o=28	0
24	1
19	2
16	3
11	4
7	5
3	6
2	7
2	8
2	9
2	10
1	11



A simple model is a half-life where half of the sample decays on average over a particular time (close to 2 flips)

$N=N_o(1/2)^{t/t_{1/2}}$ (number of half-lives)

$t_{1/2}$ is the half-life - eg carbon 14 has a half-life of 5730 years (p621) Polonium 194 has a half-life of 0.7s Plutonium 242 has a half-life of 3.79×10^5 years

HL
$N=N_oe^{-\lambda t}$
e is the natural number 2.71828...
it is special - look it up
λ= decay constant = (natural log of 2)/half-life
$=\ln 2/t_{1/2}$
$= 0.69315/ t_{1/2}$

natural log $\ln(N/N_o) = -\lambda t$
$t= - (1/\lambda)\ln(N/N_o)$
activity $A = \lambda N$

eg. A sample has 5.0 mg of Carbon 14 with a half-life of 5730 years.
a) How much of the sample is left after
i) 11460 years?
ii) 300000 years?
b) if 1/32 of the sample is left, how old is the sample?

p622 Q9-12

$N=N_o(1/2)^{(\text{number of half-lives})} =$

$N=N_o(1/2)^{t/t_{1/2}}$

i) 1.25 mg

number of half-lives = 11460/5730=2

$N=N_o(1/2))^{(\text{number of half-lives})} = 5.0\text{mg}(1/2)^2$

N=1.25mg

number of half-lives = 300000/5730=52.356

$N=N_o(1/2))^{(\text{number of half-lives})} = 5.0\text{mg}(1/2)^{52.356}$

on your calculator 5.0 x 0.5(hit y^xbutton)52.356 or the ^ button

$N=8.7\text{x}10^{-16}\text{mg}$

λ = ln(2)/5730 = 0.000120968094338559 s^{-1}

probability an atom will decay per second

N= 5xe^(-0.000120968094338559x300000)=

$N=8.7\text{x}10^{-16}\text{mg}$

b) 1/32 = 5 half-lives

5x5730=28650 years

HL way:

$t= - (1/\lambda)\ln(N/N_o)$

= -(1/0.000120968094338559)xln(1/32)=

28,650.00000000008 years

Energy

Where does the energy for radiation come from?

What happens with an electron meets a positron(anti-matter)?
They annihilate - the mass changes to energy by $E=mc^2$
E is the energy released, in Joules or MeV is mega electron volts $1MeV= 1.602x10^{-13}J$
m is mass lost - mass defect or mass annihilated in kg or u or MeV/c^2
c is the speed of light in a vacuum, $3.00x10^8m/s$

eg. An electron and positron annihilate. How much energy is given off?
mass of electron is $9.11x10^{-31}kg$ (same for positron).

p631Q13
read p631-635 CR 2.1-2.4